BALDWIN

DIESEL-ELECTRIC SWITCHING LOCOMOTIVES

OPERATOR'S MANUAL

660-1000-1500 HP

SWITCHERS & ROAD SWITCHERS

THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, PA.

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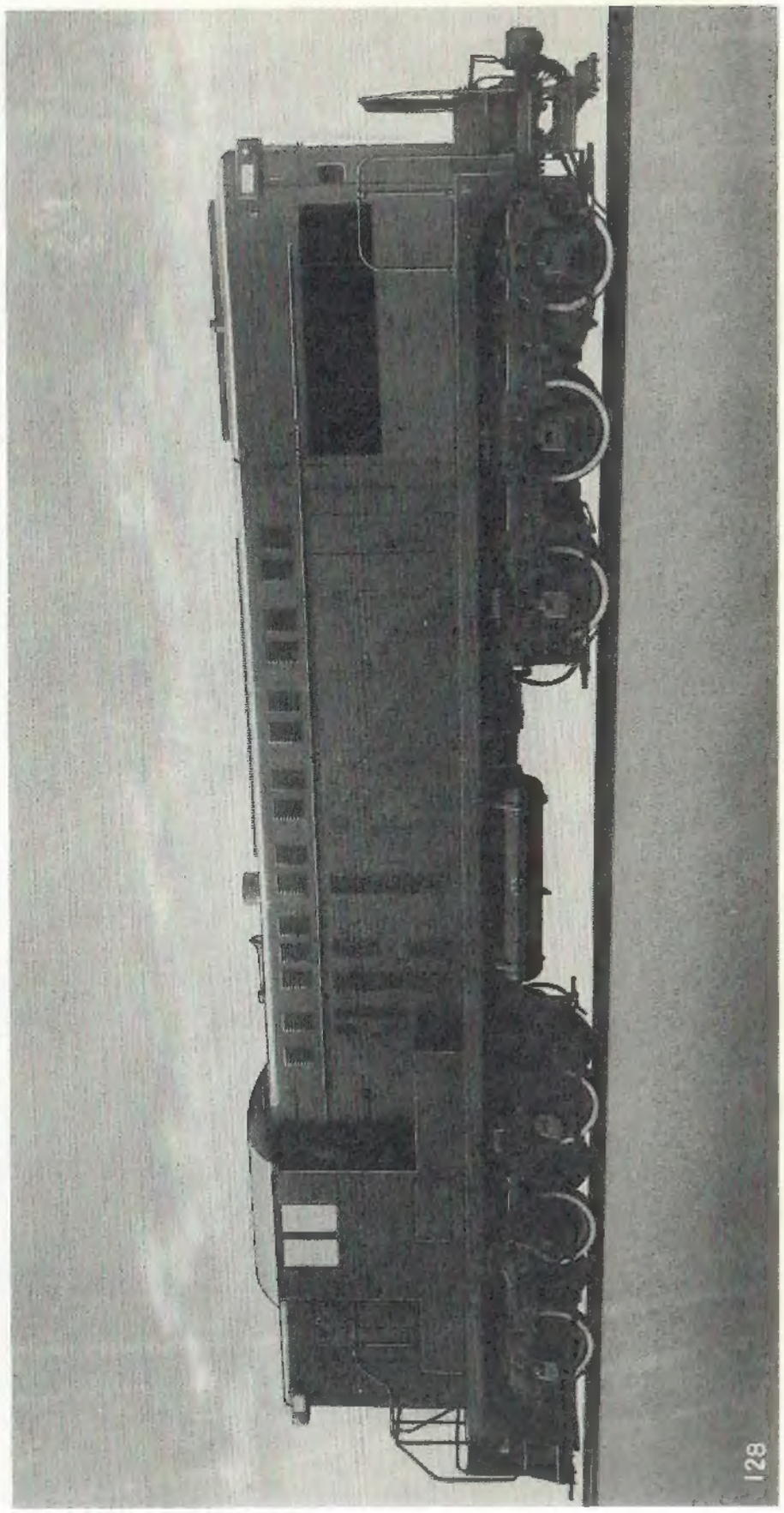
Rev. 12-1-48

SWITCHER — FIGURE 1



ROAD SWITCHER — FIGURE 2

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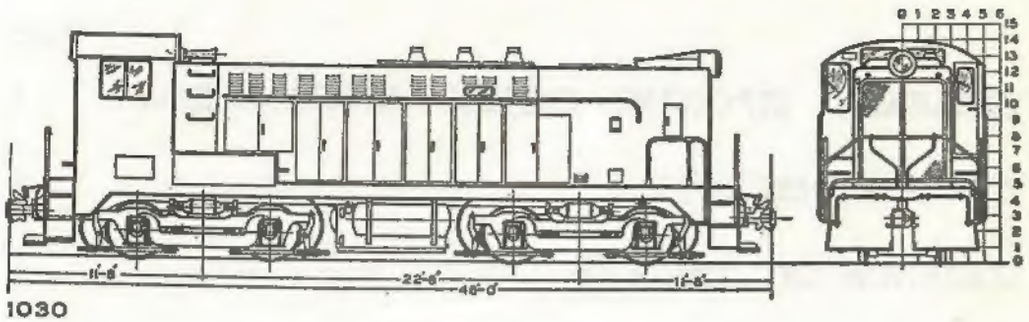

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FIGURE 3

660 H. P. SWITCHER

GENERAL SPECIFICATIONS

Driving Wheels, 4 pairs .....40 inches

Gear Ratio 14:68

Maximum Speed Restriction .....60 m.p.h.

Total Weight, in Working Order.....198,500 lbs.

Diesel Engine, one, Normally Aspirated .....6 cyl.

Supplies:

- Lubricating Oil .....165 gals.
- Fuel Oil .....650 gals.
- Cooling Water .....250 gals.
- Sand .....30 cu. ft.

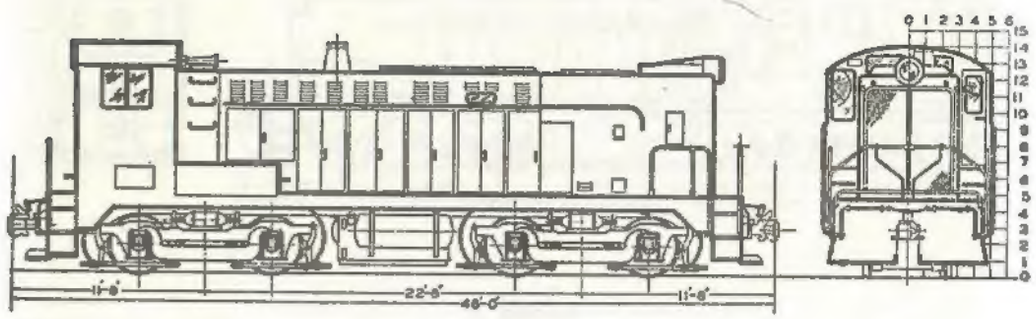

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FIGURE 4

1000 H. P. SWITCHER

GENERAL SPECIFICATIONS

Driving Wheels, 4 pairs .....40 inches

Gear Ratio 14:68

Maximum Speed Restriction .....60 m.p.h.

Total Weight, in Working Order.....235,000 lbs.

Diesel Engine, one, Supercharged.....6 cyl.

Supplies:

- Lubricating Oil .....170 gals.
- Fuel Oil .....650 gals.
- Cooling Water .....250 gals.
- Sand .....30 cu. ft.

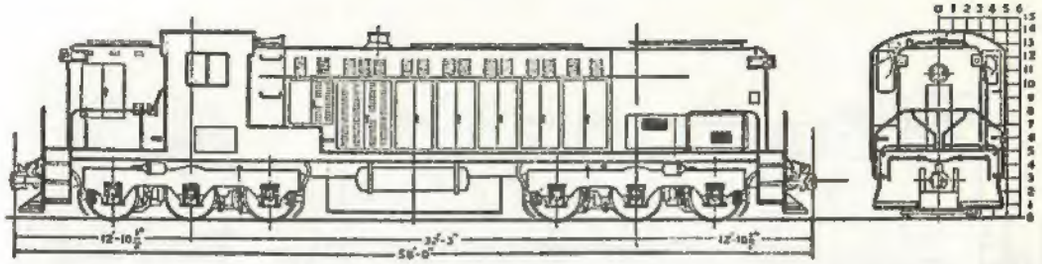

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FIGURE 5

1500 H. P. SWITCHER

GENERAL SPECIFICATIONS

Type	DRS-4-4-15			DRS-6-4-15			DRS-6-6-15
Wheels	42"			42"			42"
Gear Ratio	15:63	17:62	19:60	15:63	17:62	19:60	15:63
Max. Speed Restriction M.P.H.	65	75	82	65	75	82	60
Total Weight in Working Order	240,000 lbs.			256,000 lbs.			325,000 lbs.
Diesel Engine, Supercharged	1-8 Cylinder			1-8 Cylinder			1-8 Cylinder

Supplies:

Lubricating Oil .....200 gals.

Fuel Oil .....900 gals.

Cooling Water .....300 gals.

Sand .....30 cu. ft.

GENERAL DESCRIPTION

These locomotives are designed with all the flexibility of operation necessary for switching service. The road switcher, as the name implies, is in all essentials a road locomotive. The switcher, although not a road job, has sufficient weight, power and speed to handle moderate train movements where service requirements may frequently extend beyond yard limits.

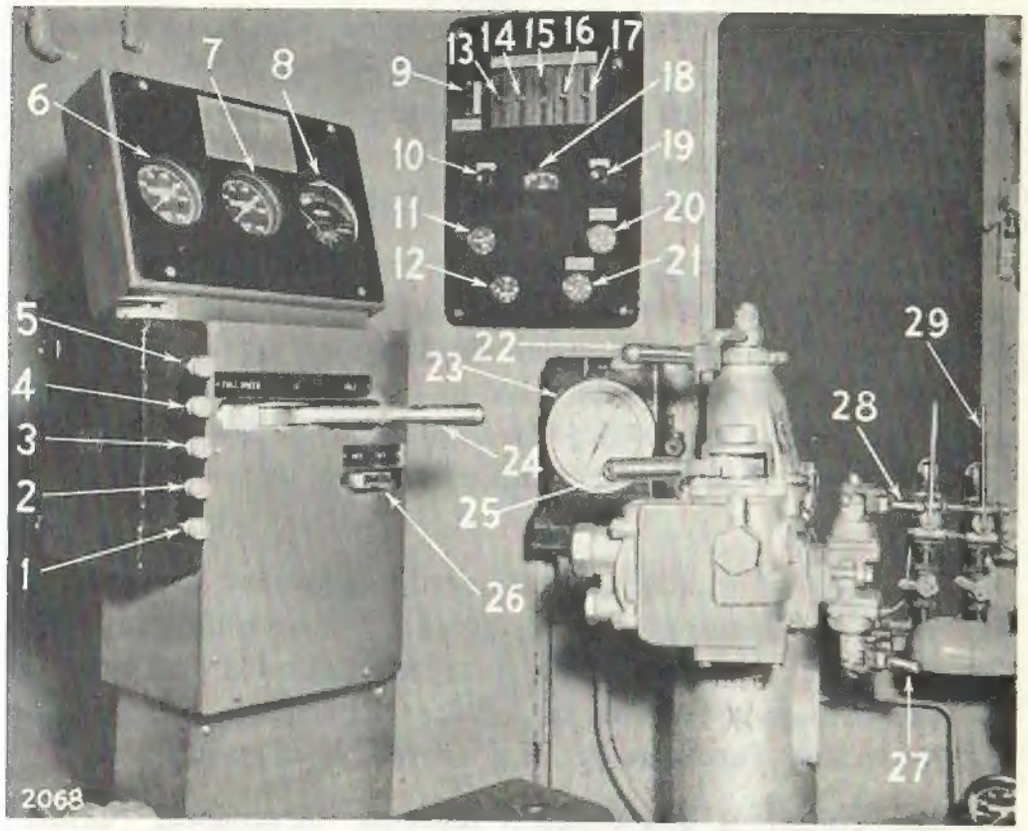
Each engine on a Diesel-Electric locomotive drives a direct connected main generator which delivers power to traction motors geared to the truck axles. Energy for starting is obtained from a storage battery connected to the main generator which acts as a motor for starting the engine. After the engines are started they are under the complete control of the engineer in the cab.

Some of the auxiliary equipment is powered by the main generator, the remainder by an auxiliary generator, which also charges the battery, energizes the control circuits and supplies the exciter 4-pole field at a regulated constant voltage. The exciter, in turn, furnishes main generator field excitation.

The electrical transmission through "Auto-Load" control protects the Diesel engine from overloads, provides maximum smooth acceleration and compensates for temperature variations, so that full engine horsepower is always available.

Most of the manual controls for the locomotive are located in the cab. Main controls are (1) the throttle, controlling power and speed, (2) the reverse lever, which determines direction of movement, and (3) the brake valves for independent and automatic braking. Push buttons on the control switch station operate the main control switch and various lights on and in the locomotive; secondary manual controls actuate sander, bell ringer and air horns.

LOCOMOTIVE — OPERATING CONTROLS



ENGINEER'S POSITION — ROAD SWITCHER

FIGURE 6

1. CAB LIGHT SWITCH
2. GAUGE & NUMBER LIGHT SWITCH
3. CLASS & MARKER LIGHT SWITCH
4. CLASS & MARKER LIGHT SWITCH
5. CONTROL SWITCH
6. BRAKE PIPE & CYLINDER PRESSURE GAUGE
7. MAIN & EQUALIZING RESERVOIR PRESSURE GAUGE
8. AMMETER
9. FAN AND SHUTTER SWITCH
10. START BUTTON No. 1
11. WATER TEMPERATURE GAUGE
12. FUEL OIL PRESSURE GAUGE
13. AUXILIARY GENERATOR SWITCH
14. ENGINE STOP SWITCH
15. HOOD LIGHT SWITCH
16. HEATERS—LEFT SWITCH
17. HEATERS—RIGHT SWITCH
18. BATTERY AMMETER
19. START BUTTON No. 2
20. LUBRICATING OIL PRESSURE GAUGE (at engine)
21. LUBRICATING OIL PRESSURE GAUGE (at turbocharger)
22. AUTOMATIC BRAKE VALVE
23. SPEED RECORDER
24. THROTTLE LEVER
25. INDEPENDENT BRAKE VALVE
26. REVERSE LEVER
27. BELL RINGER VALVE
28. SANDER VALVE
29. WHISTLE VALVE

NOTE: This illustration shows a typical control arrangement. Special equipment may be furnished with certain locomotives.

1000 H. P. SWITCHER — EQUIPMENT CABINET

(Also applies to 660 H. P. Switcher except as noted)

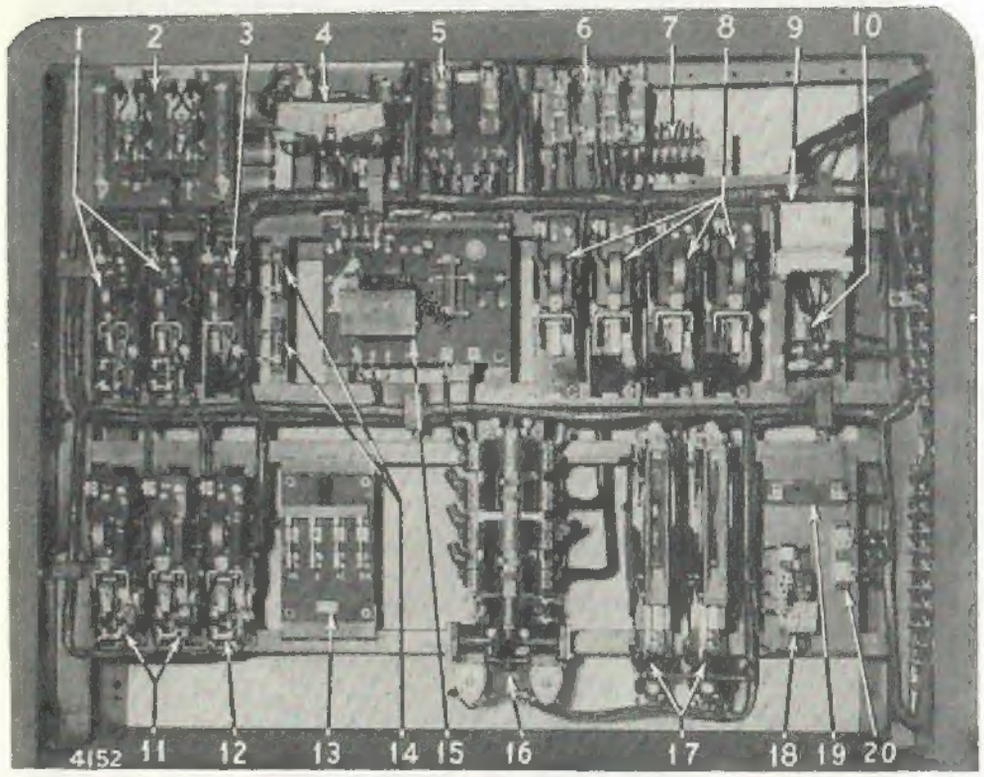


FIGURE 7

1. BATTERY PARALLEL CONTACTORS
2. TRAC. MOTOR FIELD SHUNT RELAY (only 1 step on 660 H.P.)
3. REVERSE CURRENT CONTACTOR
4. REVERSE CURRENT RELAY
5. WHEEL SLIP RELAY
6. BATTERY PARALLEL RELAY
7. RESISTOR
8. FIELD SHUNTING CONTACTORS (only 2 on 660 H.P.)
9. PNEUMATIC THROTTLE SWITCH
10. PNEUMATIC FIELD CONTROL SWITCH
11. STARTING CONTACTORS
12. BATTERY SERIES CONTACTOR
13. BATTERY SWITCH
14. TRACTION MOTOR CUTOUT SWITCHES
15. VOLTAGE REGULATOR
16. REVERSER
17. POWER SWITCHES
18. EXCITER FIELD CONTACTOR
19. AUXILIARY GENERATOR FUSE
20. BATTERY AMMETER SHUNT

NOTE: Figures 7 and 8 show typical arrangement of equipment. Maintainers and operators should refer to wiring diagrams for accurate details.

1500 H. P. SWITCHER — EQUIPMENT CABINET

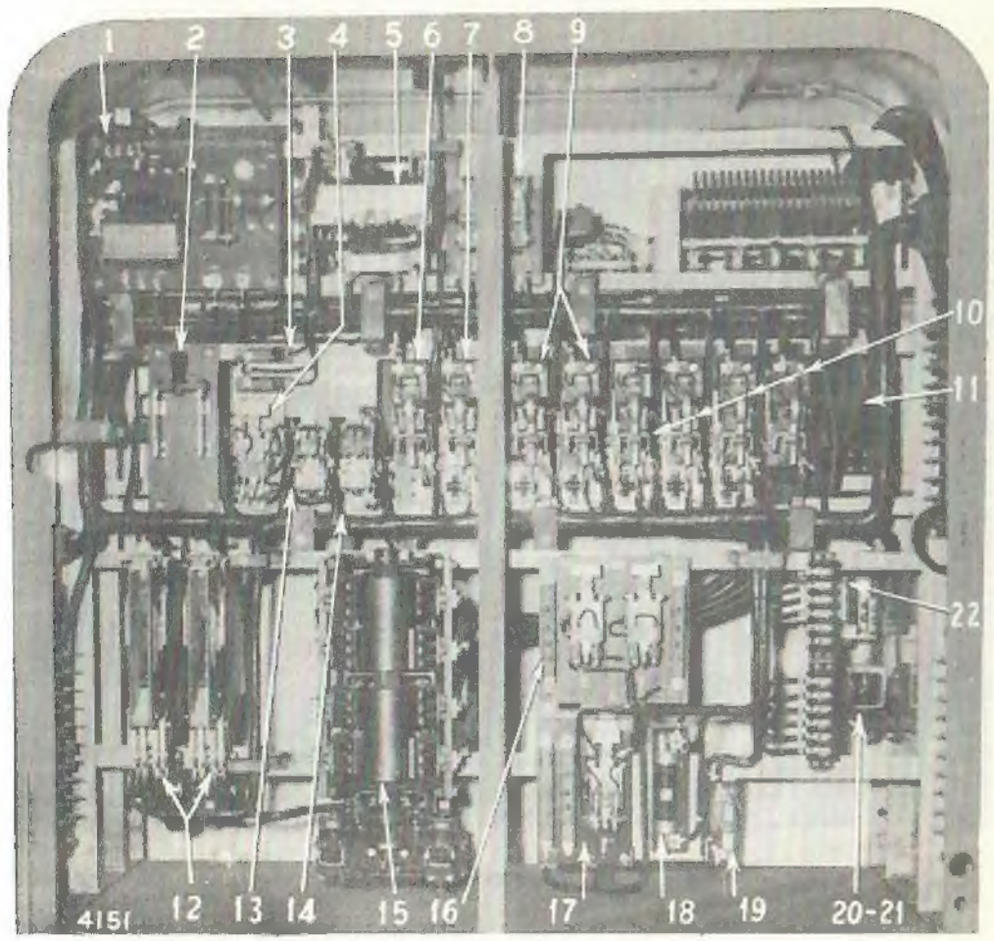
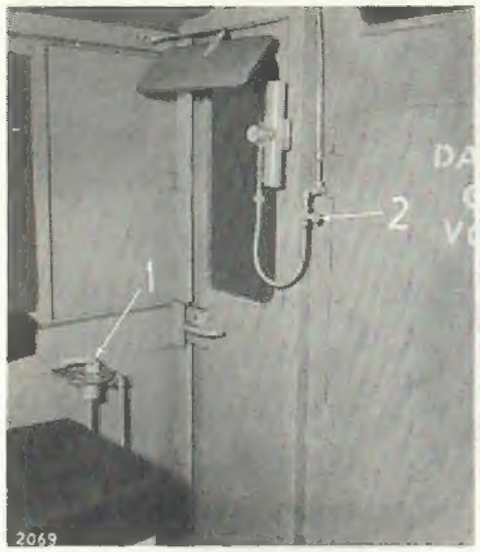


FIGURE 8

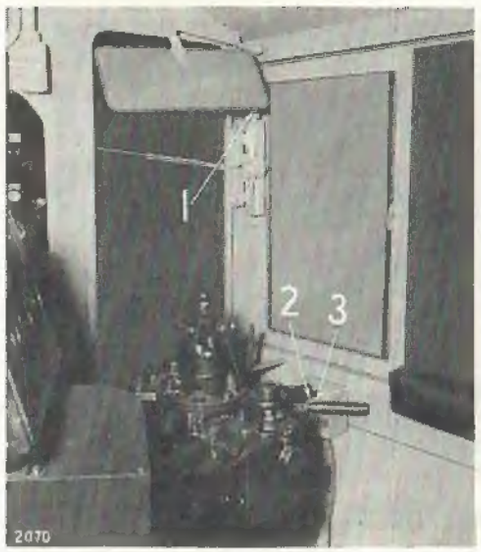
1. VOLTAGE REGULATOR
2. BATTERY SWITCH
3. TRACTION MOTOR CUTOUT SWITCHES
4. PROTECTIVE START RELAY
5. REVERSE CURRENT RELAY
6. REVERSE CURRENT CONTACTOR
7. GENERATOR FIELD CONTACTOR
8. WHEEL SLIP RELAY
9. STARTING CONTACTOR (Gen. Field)
10. FAN MOTOR CONTACTORS
11. FIELD SHUNTING AND G-STARTING CONTACTORS (mounted back-to-back with 10. Access from engine compartment).
12. POWER SWITCHES
13. POWER CONTROL CONTACTOR
14. EXCITER FIELD CONTACTOR
15. REVERSER
16. FIELD SHUNT RELAY
17. FAN FIELD SHUNT RELAY
18. FAN MOTOR FUSE
19. BATTERY CHG. FUSE
20. WHEEL SLIP VALVE
21. PNEUMATIC FIELD CONTROL SWITCH (rear)
22. PNEUMATIC THROTTLE SWITCH (rear)

NOTE: See note preceding page. Switchers equipped for M.U. operation have M.U. Switch near item 3, and Sander Valves and Control Cutout Valve near item 19.

LOCOMOTIVE — CAB DETAILS

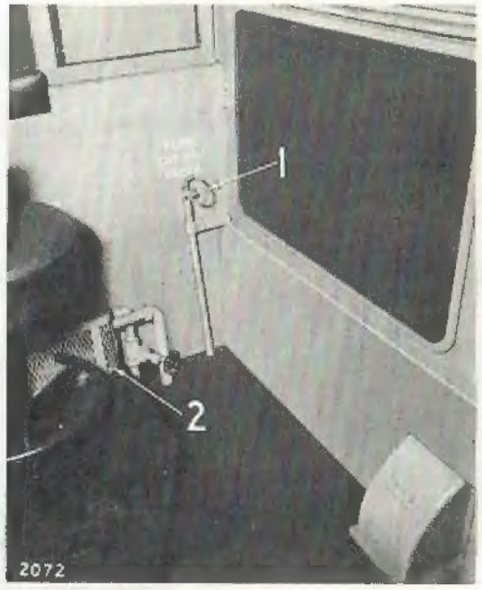


CAB—LEFT FRONT
FIGURE 9
1. BELL RINGER
2. WINDSHIELD WIPER VALVE



CAB—RIGHT FRONT
FIGURE 10
1. WINDSHIELD WIPER VALVE
2. HEATER SWITCH—FRONT
3. HEATER SWITCH—REAR

CAB—LEFT REAR
FIGURE 11
1. CAB HEATER
2. HAND BRAKE



CAB—RIGHT REAR
FIGURE 12
1. FUEL CUT-OUT VALVE
2. HEATER

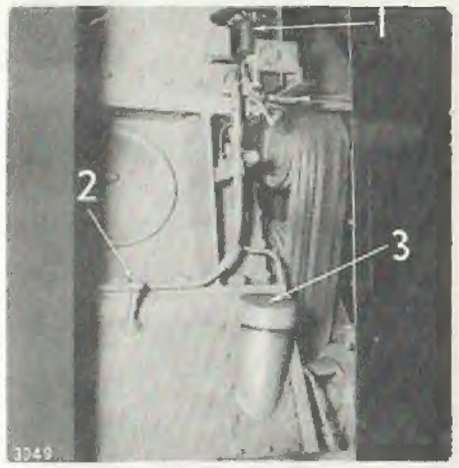
NOTE: The illustrations on this page are typical of 660 and 1000 H.P. Switchers.

DIESEL ENGINE DETAILS

RESETTING OVERSPEED STOP

FIGURE 13

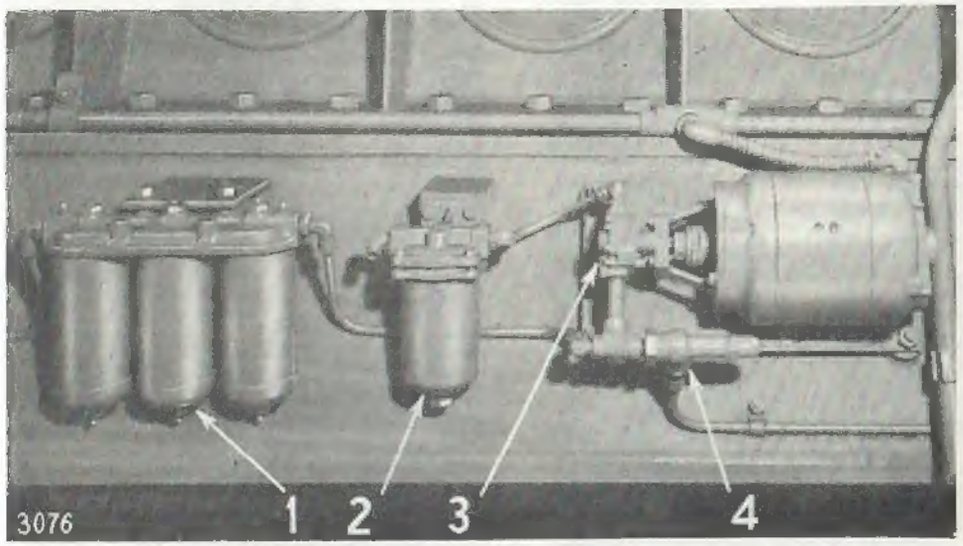
1. RESET BAR. PULL DOWN TO RESET OVERSPEED STOP



LUBRICATING OIL FILL AND LEVEL GAUGE

FIGURE 14

1. SHUT-DOWN VALVE
2. OIL LEVEL GAUGE
3. OIL FILL



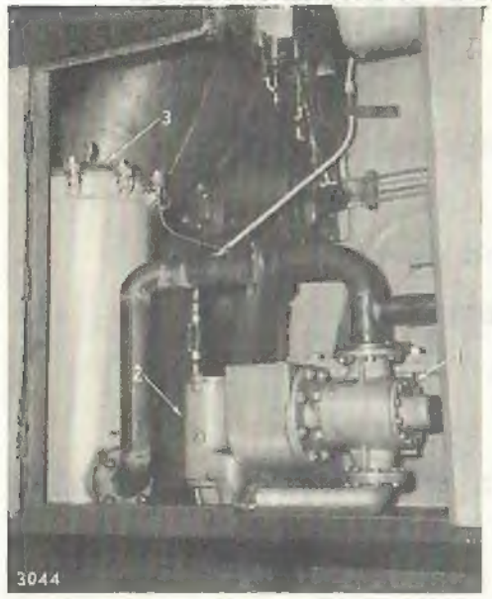
FUEL OIL SUPPLY PUMP

FIGURE 15

1. FUEL OIL PRESSURE FILTER
2. FUEL OIL SUCTION STRAINER
3. FUEL OIL PUMP
4. RELIEF VALVE

NOTE: These illustrations are applicable to 660 and 1000 H.P. Switchers and 1500 H.P. Road Switchers.

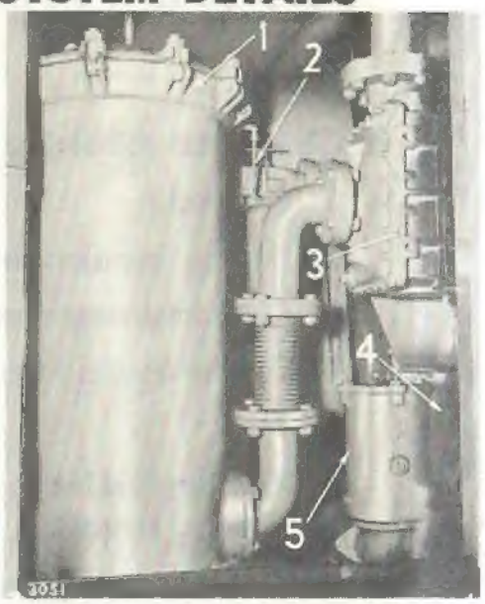
LUBRICATING OIL SYSTEM DETAILS



LUBE OIL PUMP
1500 H.P. ROAD SWITCHER

FIGURE 16

1. ENGINE DRIVEN PUMP
2. LUBE OIL SUCTION STRAINER
3. LUBE OIL FULL FLOW FILTER



LUBE OIL PUMP & HEAT EXCHANGER
660 AND 1000 H.P. SWITCHER

FIGURE 17

1. LUBE OIL FULL FLOW FILTER
2. METAL EDGE TYPE LUBE OIL PRESSURE STRAINER
3. HEAT EXCHANGER
4. LUBE OIL PUMP
5. LUBE OIL SUCTION STRAINER

LOCOMOTIVE EXTERIOR VIEWS

OUTSIDE FUEL CUT-OUT

FIGURE 18

1. EMERGENCY OUTSIDE FUEL OIL CUT-OUT VALVE

FUEL TANK

FIGURE 19

1. FUEL OIL FILL
2. FUEL GAUGE

LOCOMOTIVE OPERATION

I. Preliminary:

A. Check the following supplies:

1. Fuel oil.
2. Engine crankcase and governor oil.
3. Air compressor crankcase oil.
4. Engine cooling water.
5. Sand.
6. Heating boiler water, when a boiler is installed on road switchers.

B. Light lamps if required, by closing the corresponding switches on the control stand. The hood lights, gauge and marker lights will not burn until the main battery switch in the equipment cabinet is closed.

C. Inspect the engine, generator and other machinery for rags, tools, etc., that may have been accidentally left near moving parts.

II. Starting the Diesel Engine:

A. Close battery switch.

B. Put the throttle in the "idle position."

C. Insert reverse lever. Put it in the "off" position.

D. Close the engine stop switch on locomotives so equipped.

E. Close the control switch. The fuel supply pump should start, and a pressure of 25 lbs. minimum should be indicated on the fuel oil pressure gauges. If no pressure is indicated, check the emergency fuel cut-off valve and reset if necessary.

F. Press the engine start button and if the engine does not turn, release the button immediately. If the engine turns, hold button in until the engine fires and a

lubricating oil pressure of 20 lbs. shows on the gauge. Releasing the start button before the required pressure is indicated, permits the engine shut-down device to stop the engine. Never hold the button in longer than 10 seconds because continued cranking will run down the battery. See page 43 if engine does not turn.

Some locomotives are equipped with two start buttons. Press No. 1 start button until the engine turns. If the engine does not fire press No. 2 start button while holding No. 1 button in. This will crank the engine faster.

G. Check the lubricating oil pressure gauge. It must register a pressure between 20 and 65 lbs. when engine is operating at rated speed and normal operating temperatures have been reached.

H. Close the auxiliary generator switch at engineer's position. The auxiliary generator will begin to charge the battery. The charging rate will register on the battery ammeter and should range between 0 and 28 amps. As the battery becomes fully charged, the charging rate will decrease and approach zero. The battery ammeter should never show a discharge when the engine is running. Report to Maintenance if this condition exists.

I. Let the engine idle until the water temperature reaches 120°F.

III. Pumping Air:

A. As the engine runs, the air compressor will pump air into the main reservoirs. Check the main reservoir air pressure to be sure the compressor stops pumping when the governor cut-out setting of 140 lbs. is reached.

B. Air may be pumped at a higher rate if desired by bringing the engine speed above idling as follows:

1. Leave the reverse lever in the "off" position.

2. Increase the throttle setting, speeding up the engine and the compressor, until the pumping rate desired is reached. Never move the throttle more than ¾ open for this purpose.

3. Return the throttle to the "idle" position when air pressure gauge registers required pressure.

C. Be sure the air compressor resumes pumping when the main reservoir pressure drops to the lower governor setting of 125 lbs.

D. Check the control air pressure on the gauge in the equipment cabinet. It should be 70 lbs.

IV. Moving the Locomotive:

A. With the throttle in the "idle" position and the reverser "off."

1. Check the traction motor cut-out switches in the control cabinet, making sure they are closed.

2. Check the traction motor blowers, making sure they are operating properly.

3. Check the radiator fan.

a. On some locomotives it is belt driven from the engine and should be operating.

b. On other locomotives there are two motor driven fans which may or may not be operating depending on the cooling water temperature. Check the emergency fan switch in the equipment cabinet. It should be closed in the "up" position for automatic operation.

c. On locomotives equipped for multiple operation check the multiple unit switch in the equipment cabinet, making sure it is in the "single unit" position.

4. Check for any leaks in fuel, water and lubricating oil piping.

5. Test the automatic and independent air brakes, making sure they apply and release properly. Release brakes.

B. Move the reverse lever to the "forward" or "reverse" position according to the direction the locomotive is to travel.

C. Move the throttle slowly from the "idle" position until a current flow shows on the load ammeter. If the train is not too heavy nor the grade severe the locomotive will move. If the locomotive does not move, return the throttle to "idle" immediately. This should be done before proceeding further, as serious harm can be done to the electrical apparatus. See page 43.

D. When the meter registers current and the train starts to move, slowly move the throttle to the position required for the train acceleration desired.

E. The throttle should be moved slowly to prevent the wheels from slipping. If the wheels should slip, the wheel slip buzzer will sound and the Diesel engine speed will automatically decrease until the slipping stops. If wheels slip again, retard the throttle until wheel slip stops.

F. The high starting tractive effort of the Diesel-Electric locomotive makes use of sand seldom necessary.

CAUTION: Do not apply sand while the wheels are slipping. Always use sand sparingly.

If sand is necessary, it may be applied as follows:

1. On locomotives equipped with hand sanding, moving the sanding lever to the "forward" position will apply sand in front of both trucks; and moving the lever to the "reverse" position will apply sand to the rear of both trucks.

2. On locomotives equipped with electric sanding, depressing the sander foot switch will sand either the front or the rear of both trucks, depending on the position of the reverse lever.

G. As train speed increases the traction motor fields are automatically weakened by shunting the field windings with resistance, rendering it possible to run at higher speeds. Amperage increases at time of shunting.

H. LOAD LIMIT. Excessive loads will heat electrical equipment enough to result in serious damage and failure. The damage may not be apparent immediately but can cause failure later. Electrical apparatus will safely carry an overload for a limited time if maximum allowable temperature has not been reached. The following table gives typical time-load limitations if the equipment has not recently been subject to heavy loads and heating. Typical examples of operating requirements in this respect are:

Overload is Permitted

1. If the engine has idled for 15 minutes or more just previous to the overload.
2. If, during the preceding hour, the locomotive has averaged about half of continuous rating.

No Overload is Permitted

1. If the locomotive has been operating at or near continuous rating for one hour or more.
2. If an overload has existed for the period of time specified in the foregoing table.

When the time limit is reached for any overload, the engine must be idled for 15 minutes to cool the equipment unless the train can continue *at full engine speed* at or below the continuous rating. No overload capacity exists at any other amperage above continuous rating. The generator may operate continuously at full engine speed at, or below, the continuous rating. The crew should pay careful attention to load limits in any abnormal operation for which the railroad has no established tonnage ratings, as when a traction motor is cut-out (See VI following).

TIME-LOAD LIMITS

Time Limit	Amperes For 660 H.P. and 1000 H.P. Switchers	Amperes For 1500 H.P. Switchers
Continuous Rating	1050	1850
Overloads		
30 Minutes	1100	2000
20 Minutes	1150	2100
10 Minutes	1300	2350
5 Minutes	1450	2650

V. Inspections During Operation:

A. Rotate the handle on the metal edge lubricating oil strainer two full turns every 4 hours.

On locomotives equipped with a lubricating oil heat exchanger this strainer is located in the radiator compartment and is accessible thru a door provided in this compartment.

B. Check the cooling water level on the gauge at expansion tank every 8 hours. Level must be maintained so that water is visible at all times in the gauge glass.

C. Check the lubricating oil level once every 8 hours, with the engine stopped. It must be maintained above the "low" mark on the bayonet gauge.

D. Drain the main air reservoirs once every 8 hours.

E. Make periodic visual inspection of equipment under the locomotive for loose or dragging parts.

F. Check the lubricating oil pressure and water temperature frequently. The lubricating oil pressure should range between 20 and 65 lbs. and the water temperature should stay between about 150° and 190° F. (see page 30).

G. Investigate any unusual noises or odors immediately and report to maintainer.

H. Check that battery is not discharging.

VI. Cutting Out a Traction Motor:

A. Should a failure occur in a traction motor it may be taken out of service by opening the traction motor cut-out switch in the equipment cabinet.

1. Return the throttle to "idle" position and put the reverse lever in "off" position.

2. Open the proper traction motor cutout switch.

a. On 4-motor locomotives, No. 1 switch cuts out No. 1 and No. 3 motors. No. 2 switch cuts out No. 2 and No. 4 motors. Motors are numbered in sequence from front to rear.

b. On 6-motor locomotives, No. 1 switch cuts out all motors on front truck. No. 2 switch cuts out all motors on rear truck.

NOTE: When operating with a set of traction motors cut-out, do not exceed ½ of the normal current rating on the load ammeter. Current is automatically reduced without corresponding reduction in throttle setting.

B. Do not try to rerail a locomotive under its own power, as serious damage may result to the traction motor from spinning the wheels. However, if only one pair of wheels is derailed it is possible to rerail the locomotive under its own power by cutting out the motor driving the derailed wheels.

VII. Stopping the Locomotive:

A. Move the throttle to the "idle" position.

B. Apply the brakes.

1. Do not use the independent air brake to stop a heavy train; use the automatic brake.

2. Never apply brakes unless throttle is in "idle" position, as this may result in an overload.

C. If the locomotive is to be left standing temporarily,

1. Put the reverse lever in the "off" position.

2. Apply the hand brake.

VIII. Reversing the Locomotive:

A. Bring the locomotive to a full stop as outlined in section VII above.

B. Move the reverse lever for operation in the opposite direction.

C. Release the brakes.

D. Move the throttle slowly toward the full speed position.

CAUTION: Never move the reverse lever while the locomotive is in motion as this may result in serious damage to the electrical equipment.

IX. Shutting Down the Locomotive:

A. Let the engine idle for at least ten minutes.

B. Open the engine stop switch on locomotives so equipped.

C. Open the control switch.

D. Open the auxiliary generator switch.

E. Open the main battery switch.

F. Set the hand brake and release the air brakes.

G. Turn off all lights.

H. Remove reverse lever.

J. If the locomotive will be exposed to freezing temperatures take the necessary precautions (page 30).

X. Shutting Down Engine in an Emergency:

A. Open control switch or the engine stop switch.

B. Pull the red emergency fuel cut-out valve handle in the right rear corner of the cab, or on the outside of the locomotive. The emergency cut-out valve on the outside of the locomotive is located on the right rear side.

C. It will be necessary to reset the fuel cut-out valve before starting the engine. Put the throttle in the "idle" position, and put the reverse lever in the "off" position before restarting.

XI. Multiple Unit Operation:

A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.

B. Open the cocks at the end of the air lines on both locomotives in the following sequence: throttle line, main reservoir line, equalizing pipe and train line.

C. On trailing or non-controlling unit.

1. Close the double heading cock on the brake pedestal.
2. Put the automatic brake in "holding" position.
3. Put independent brake in the "release" position.
4. Put the "Transfer Valve Operating Cock" (located on the Control Stand) in the "trailing" position.
5. Put the throttle in the "idle" position.
6. Put the reverse lever in the "off" position and remove the handle.
7. Close the multiple unit switch in the equipment cabinet to the "M. U." (Multiple Unit) position.
8. Close the main battery switch in the equipment cabinet.
9. Open "control switch" and lock in place.
10. Release the hand brake.

D. On the leading or controlling unit make sure the multiple unit switch is closed in the "S" (Single Unit) position.

1. Close main battery switch.
2. Put the "Transfer Valve Operating Cock" (located on the control stand) in the "lead or dead" position on the controlling unit.
3. Open double heading cock on brake pedestal.
4. Close "control switch".

E. Start the engines as previously outlined. It will be necessary to start the engine in the trailing unit from its cab after starting the engine in the leading unit. However, in the trailing unit, leave the control switch open.

F. Close the auxiliary generator switch in the trailing unit.

G. The locomotives may now be operated in the same manner as a single unit. The sander foot switch will apply sand to the front or rear of both trucks on both units as determined by the position of the reverser.

H. The cock located above the DKR Distributing valve under the skirt of the cab is to remain open at all times except when the locomotive is to be towed dead in a train at which time it is to be closed.

XII. Procedure for Changing Operating Cab:

A. Moves required in present operating cab.

1. Make at least a 20 pound reduction with automatic brake valve.
2. Place double heading cock in cutout position.
3. Move automatic brake valve handle to "holding" position and independent brake to "release" position.
4. Move "Transfer Valve Operating Cock" to the "trailing" position

B. Moves required in leading or operating cab.

1. Move independent brake valve handle to full "application" position, move automatic brake valve handle to "running" position.
2. Cut in double heading cock, horizontal position.
3. Move "Transfer Valve Operating Cock" to "lead" position.
4. Push in control button on throttle stand.

5. Change multiple unit switch from "M.U." to "S" position.

C. Moves required in trailing or former operating cab.

1. Change multiple unit switch from "S" to "M.U." position.
2. Pull out control button and lock in position.
3. Units are ready for multiple operation.

XIII. Pusher or Double Heading Service:

A. Close the double heading cock and place handles of both brake valves in the running position.

B. Put the "Transfer Valve Operating Cock" (located on the control stand) in the "lead or dead" position.

C. The power controls may then be used in the normal fashion and the brakes will be controlled on both units by the leading locomotive.

FUEL OIL SYSTEM

Fuel is drawn from the tank under the center of the locomotive through the emergency fuel shut-off valve and the suction strainer by the motor driven fuel oil supply pump. The pump then forces the fuel through the pressure filter to the fuel header supplying the injection pumps. A pressure relief valve holds the fuel pressure in the header to 25 lbs., bypassing the excess fuel back to the tank. The supply pump is protected against pressure by a relief valve connected to its discharge.

The fuel tank may be filled on either side of the locomotive. Fill the tank slowly and watch the level gauge at top of tank to avoid overflowing.

The fuel pressure filter cartridges should be renewed at least every fifteen days, and the suction filter should be cleaned weekly.

ENGINE SHUT-DOWN DEVICE

The engine shut-down device provides for protection of the Diesel engine against low lubricating oil pressure and on some locomotives against overheating of the cooling water. It is operated by fuel oil pressure and is actually part of the fuel oil system.

A three-way magnetic valve is supplied with fuel oil from the pump discharge. This valve is energized when the lubricating oil pressure is over 20 lbs. and the cooling water temperature is less than 190°F. When energized the fuel is permitted to flow through the valve to the shut-down cylinder, releasing the fuel control shaft and allowing it to act according to the demands of the governor. Should the lubricating oil pressure fall below 20 lbs. or the engine overheat, the valve will be de-energized, closing the fuel supply to the cylinder and allowing the fuel in the cylinder to flow back to the tank. This will cause the spring in the shut-down cylinder to push the piston out and move the fuel control shaft to the "off" position, shutting down the engine.

When the engine start button is held in, these protective switches are shorted out, so that the engine may be started.

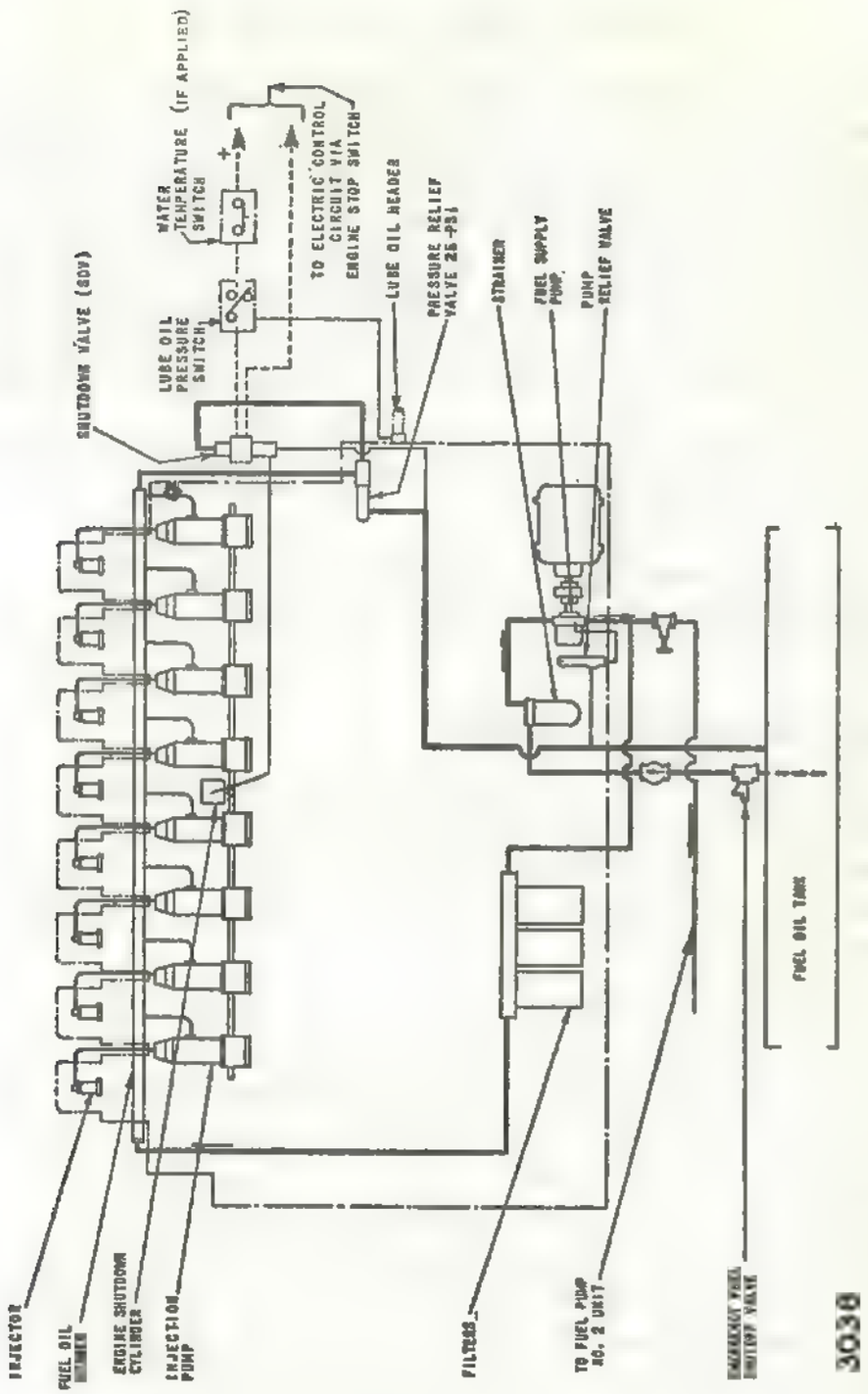


DIAGRAM OF FUEL OIL SYSTEM

FIGURE 22

LUBRICATING OIL SYSTEM

The lubricating oil is drawn from the sump, formed by the bedplate of the engine, through a suction strainer by the engine driven pump. The pump forces the oil through an oil filter, a metal edge oil strainer, and through the heat exchanger (on 660 and 1000 switchers the heat exchanger is located between pump and oil filter). The oil is then delivered to the engine header, which distributes the oil to all parts of engine requiring lubrication.

MAINTENANCE

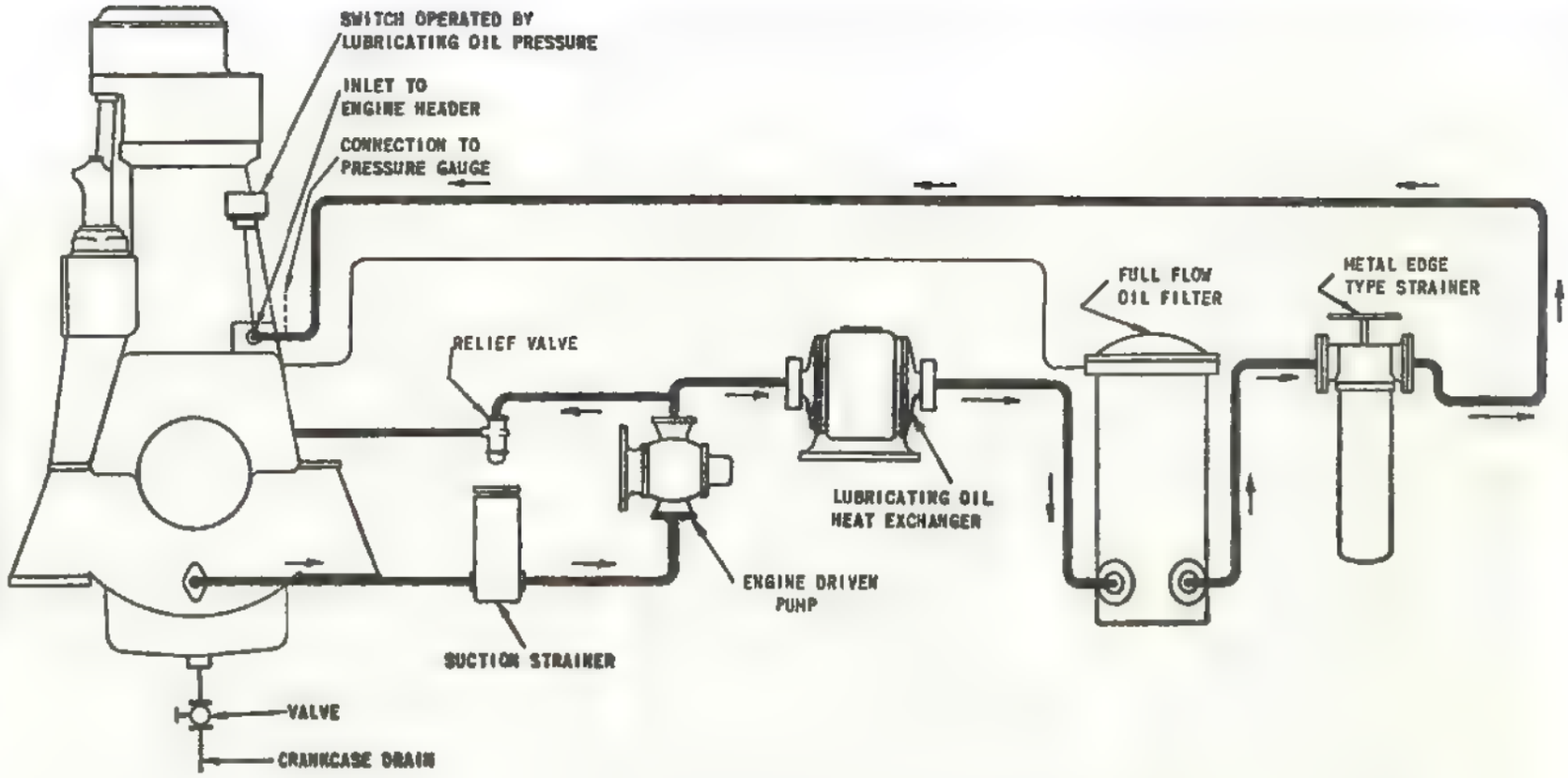
The oil level in the sump should be checked daily and must be maintained above the "Low" mark. The handle on the metal edge type strainer must be rotated every four hours.

To fill the crankcase, pour the proper type of oil through the filler pipe. Fill to the "Full" mark on the bayonet gauge. To drain oil from the engine, open the drain valve and remove the plugs from the bottom of the camshaft trough. Drain the oil into a suitable container. Also, be sure to drain the strainers, the filter and the heat exchanger, when changing crankcase oil.

Refer to Maintenance Bulletin No. MBD-131 for lube oil filter maintenance instructions.

LUBE OIL PRESSURE SWITCH

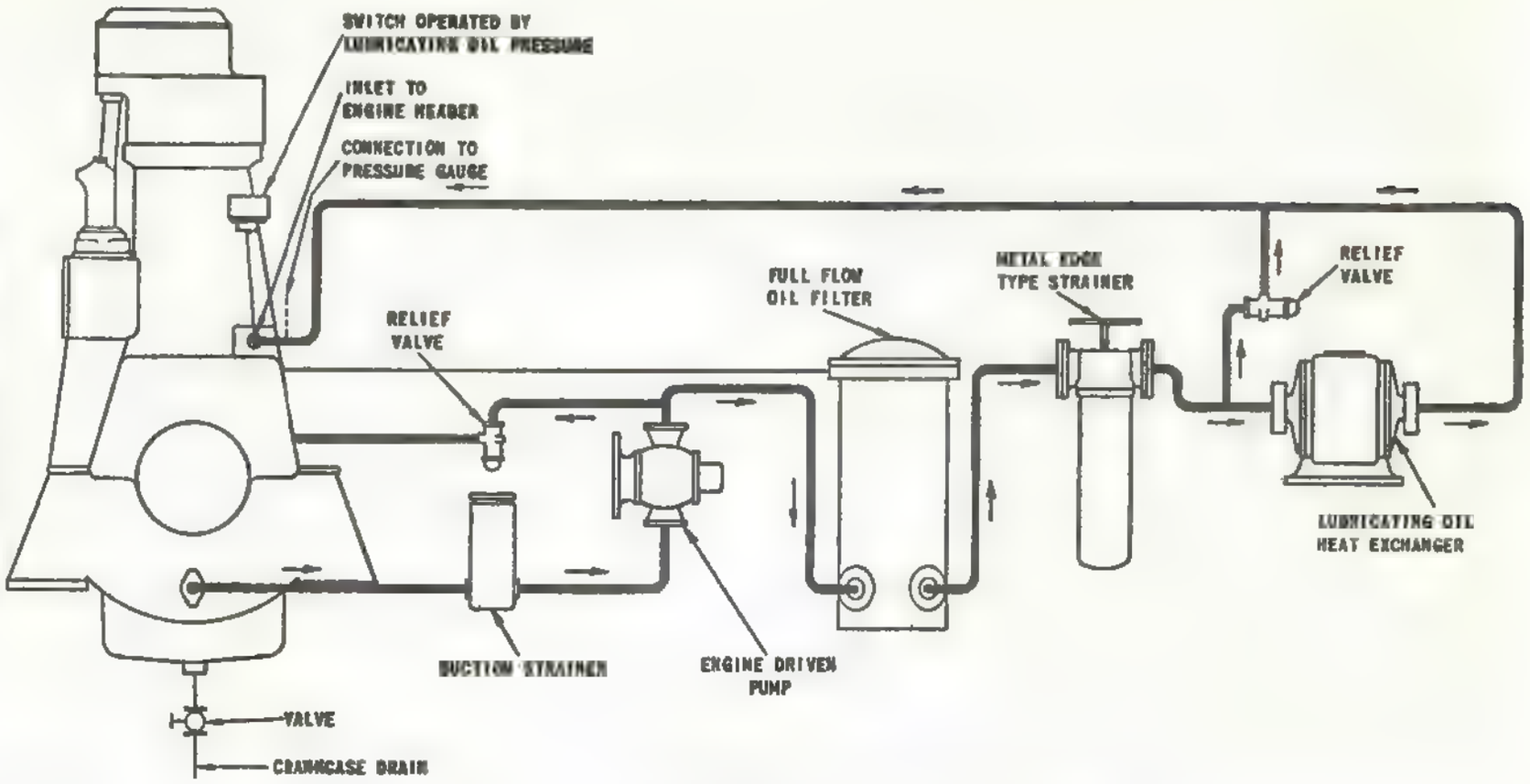
The lube oil pressure switch is a protective device which is kept closed by oil pressure (See Figures 23, 24), but opens when the lubricating system fails from loss of pressure. When this switch is closed, shutdown valve SDV is energized which is necessary to maintain the fuel supply to the engine (See Figure 22). When the switch opens, SDV is de-energized and the engine stops, as just described under engine shutdown device in the text on the Fuel Oil System.



LUBRICATING OIL SYSTEM
660 AND 1000 H.P. SWITCHERS
FIGURE 23

DIAGRAM OF LUBRICATING OIL SYSTEM

BALDWIN



LUBRICATING OIL SYSTEM
1500 H.P. ROAD SWITCHER
FIGURE 24

DIAGRAM OF LUBRICATING OIL SYSTEM

BALDWIN

ENGINE COOLING WATER SYSTEM

Water is circulated thru the engine, heat exchanger and cooling radiator by an engine driven pump, see Figures 25 and 26. An expansion tank vented to the atmosphere through an overflow pipe acts as a reservoir for maintaining the system full. The level of water in the expansion tank should be checked every 8 hours. The level must be maintained above the "low" mark on the gauge glass.

To fill the system, add water through the connection located over No. 1 truck on right side of the locomotive. Run water until water spills through the overflow pipe. The system can be filled through the filler on the roof near the front, but it is not recommended because of the danger of trapping air in the system. If the engine should overheat because of low cooling water level, the engine should be allowed to idle and hot water should be added if possible. If it is necessary to use cold water, it should be added very slowly.

If the locomotive is to be left standing exposed to freezing temperature, it will be necessary to drain the cooling system or use an outside source of steam to prevent freezing. (See page 34 also.) If a steam source is available, connect it to the drain pipe through a check valve so that the water can not back up into the steam line. Open the drain valve enough to allow steam to enter the system. To drain the system, open the drain valve.

AUTOMATIC TEMPERATURE CONTROL WITH AN ENGINE DRIVEN RADIATOR FAN

On some locomotives, the cooling water system incorporates a fan, V-belt driven from the engine, and continuously engaged. Automatically controlled shutters remain closed until water temperature reaches 160 degrees, at which time the shutters open. The shutters close when water temperature drops to 153 degrees. Temperature may rise to 190° or 200° F. with safety, at which point a water temperature switch (Figure 22, if applied) opens automatically to shut down the engine (See page 25).

In case of overheating caused by failure of the shutters to open, the manual control valve should be opened. It is

located on a stiffening member just inside the left front hood door.

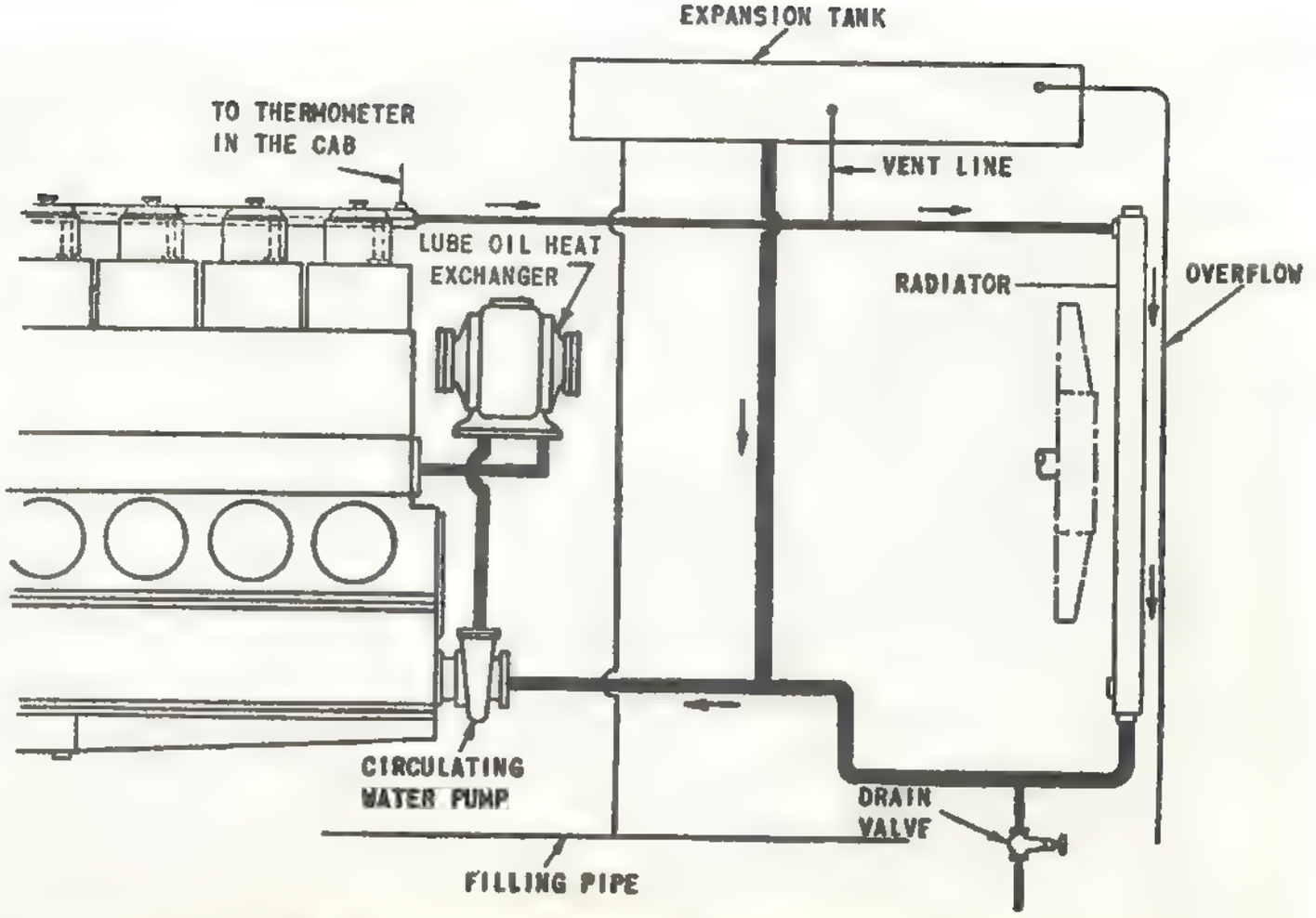
AUTOMATIC TEMPERATURE CONTROL WITH MOTOR DRIVEN RADIATOR FANS

On other locomotives, motor driven radiator fans are controlled by temperature switches which automatically change fan speed and shutter position, providing the 3-position fan and shutter switch is in "auto" position. When the water temperature rises, the thermostat decreases the air pressure to the pneumatically operated temperature switches. At 154° F., the first temperature switch closes, which opens the shutters and starts the fans at slow speed. At 156° F., the second temperature switch closes and the fans run at intermediate speed. At 158° F., the third temperature switch closes which shunts the fan motor fields, and causes fans to operate at full speed. When the water cools the foregoing sequence takes place in reverse order at approximately 155°, 153° and 151° F.

In addition to the shutters and fans controlling the water temperature, a butterfly valve is mounted in the water discharge pipe of the engine. This butterfly valve is actuated by an air cylinder which is controlled by a temperature switch. This switch is set to open the valve at 160° so that the temperature of the water in the engine will not drop too low when operating during extremely cold atmospheric temperatures.

Under heavy load, temperatures may continue to rise above 158° F. Safe operation is possible up to 190° or 200° F. at which point the water temperature switch (Figure 22, if applied) is set to automatically open the circuit to the shutdown device (See page 25).

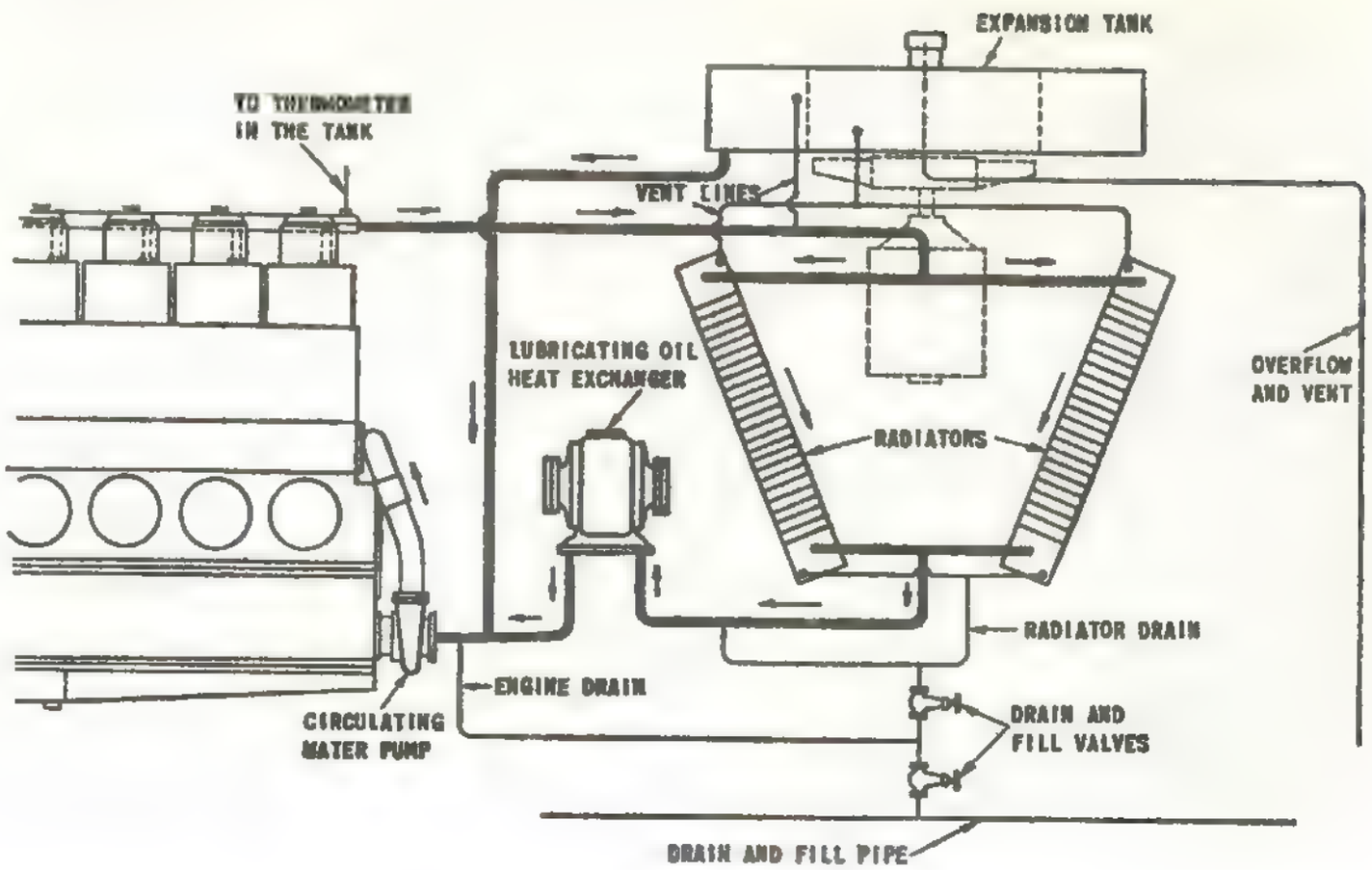
When the automatic system does not function properly, check fan motor fuses if fans are not running. Non-automatic cooling may be had by moving the 3-position switch to the "on" position. The fans will run at intermediate speed and the shutters should open. However, the shutters can be set manually in any position desired by disengaging the shutter control handle from its quadrant, and moving it as required. When the 3-position switch is in "off" position, the fans stop and the shutters close.



3048 DIAGRAM OF ENGINE COOLING WATER SYSTEM

COOLING WATER SYSTEM
660 AND 1000 H.P. SWITCHER
FIGURE 25

BALDWIN



3042 DIAGRAM OF ENGINE COOLING WATER SYSTEM

COOLING WATER SYSTEM
1500 H.P. ROAD SWITCHER
FIGURE 26

BALDWIN

On Switchers (660 and 1000 H.P.) and 1000 H.P. Road Switchers the heat exchanger is mounted above the lube oil pump on the engine. If the locomotive is to be left standing exposed to freezing temperature be certain to use the drain cock on the underside of the heat exchanger to remove all water. This must be done separately since the heat exchanger will not drain properly when the remainder of the system is drained.

ELECTRICAL SYSTEM

An electrical drive is the most practical means of transmitting Diesel engine power to the driving wheels, and electro-pneumatic controls provide the simplest means of handling both the propulsion motors and the auxiliary equipment. Normal operations are controlled by a throttle, a reverser lever, and a braking system which are handled in about the same manner as on other prevalent types of railroad motive power. After the manually operated switches are set for normal operation, and the engine started as previously described herein, the various operations controlling power, speed, field shunting, engine cooling, etc., occur automatically.

Operating men should have some fundamental knowledge of the electrical system. They are then more competent to handle the controls, watch indicating instruments for prevention of trouble, and meet non-routine operating conditions when they arise.

Most of the instruments and routine controls are mounted on panels in front of the engineer. An illustration of the inside of the equipment cabinet near the front of this book shows most of the other electrical control equipment on the locomotive. These controls should be thoroughly understood before investigating or repairing any trouble. There is high voltage on much of this equipment and no attempt should be made to enter the cabinet without taking proper safety precautions.

The main generator supplies high voltage power to the traction motors (and fan motors, if any). See Control System Diagram Fig. 27. The auxiliary generator charges the battery and supplies low voltage power (about 75 volts) to the lighting and control circuits and the 4-pole exciter field circuit. When more than one Diesel engine is controlled from one controller, the only electrical connections between units are low voltage control circuits.

The principal types of control equipment function as follows.

Relays—A relay is a coil which opens or closes a set of

comparatively light-duty contacts (generally in a controlling circuit). The coil may be in either the high or low voltage circuit and may be adjusted to pick-up or drop-out at various voltages, and calibrated to respond to varying operating conditions. As the name implies, it relays an impulse to other equipment (mostly contactors), and more than one contactor may be controlled by a single relay.

Contactors—A contactor is a coil-operated set of contacts (generally heavy-duty, and in the circuit being controlled). Its closed or open positions generally depend on whether it is energized or de-energized. There is usually no adjustment for intermediate voltages or currents, because the more sensitive relays are used for such purposes. Light-duty contacts on a contactor are called interlocks which are described in the next paragraph.

Interlocks—An interlock is a cam operated auxiliary contact whose open or closed position depends on the position of the main contacts. It is frequently necessary to prevent the closing of a certain circuit (call it "a") unless a certain other circuit (call it "b") is open (or closed, depending on design or sequence). An interlock on a contactor in "b" can be wired to control the circuit leading to "a" to achieve the desired results. They generally follow the cam by spring action, and the chief concern to the operator is that sluggish or faulty action can cause faulty locomotive operation.

Electro-pneumatic Valve—An electro-pneumatic valve (or magnet valve) consists of an electrical coil in a controlling circuit which controls valves for the pneumatic operation of certain equipment. For example the reverser and the power switches are pneumatically operated by a valve which is built into the equipment. Control air pressure is maintained from the main air reservoir, but at a lower pressure.

Breaker-type Switch—Some manually operated switches open automatically when overloaded, and should be checked if the circuits involved are not functioning. They must be moved to full "off" position before being reclosed.

Fuses—A burned-out fuse in the auxiliary generator circuit, or behind the control pushbutton will interfere with the operation of the locomotive. The same is true of a burned-out fuse feeding the fan motor (1500 H.P. only) as soon as hot water actuates the safety devices. Various lighting circuits are fused independently in order to localize trouble as much as possible.

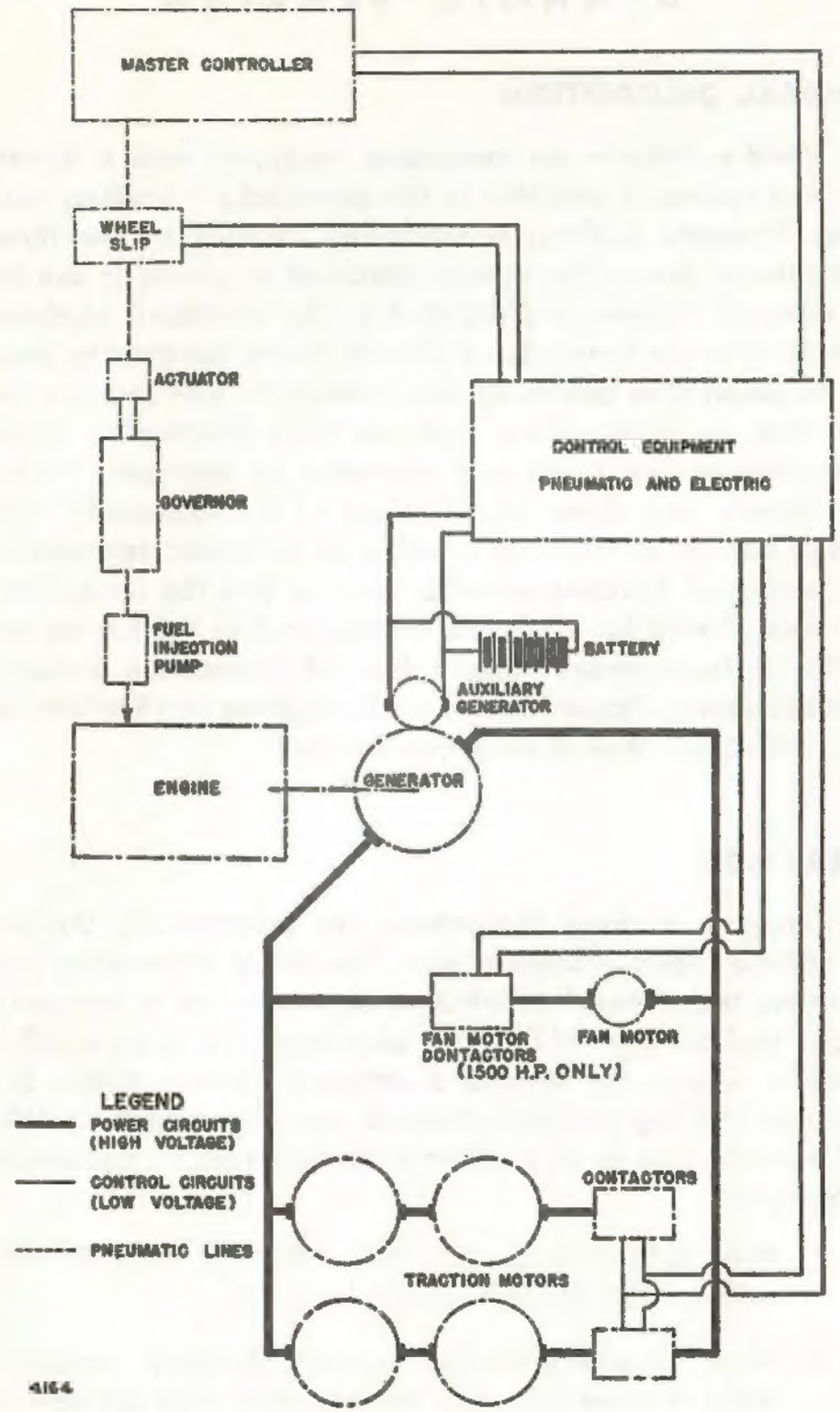
Voltage Regulator and Battery Protection—A voltage regulator holds the auxiliary generator voltage constant over the normal speed range of the Diesel engine. It is set slightly above battery voltage so the battery will receive a charge if necessary. The battery is protected against discharge through an idle or defective auxiliary generator by a reverse current relay which opens a contactor in the circuit if a reverse current flows. This contactor closes automatically any time auxiliary generator voltage exceeds battery voltage. Operators should not change the adjustment or setting of this equipment.

CONTROL SYSTEM

A diagram of the principal equipment in the control system is shown in Fig. 27. Many details are purposely omitted so that the essential relationships are more easily understood. The master controller consists principally of a throttle and a reverse lever. A condensed sequence of operations follows:

Stage of Operation	*Electrical Action*	*Pneumatic Action*
Starting	Main generator is connected to battery (wires not shown in diagram). It acts as motor to turn or crank the engine. Other generator connections are open. Battery automatically disconnected (on 1500 H.P.) as soon as engine runs.	None.

Engine Idling	After starting and closing auxiliary generator switch, auxiliary generator is connected to battery. Main generator field and exciter field energized by automatic closing of field contactors, if fans are electrically driven.	None.
Engine Cooling (1500 H.P.)	Fan motor contactors (F) close and fans operate whenever radiators are hot enough. Fan speed is automatically changed by temperature switches which energize various combinations of F contactors.	A magnet valve controls the shutters.
Reverse Lever set to change direction.	Reverser magnet valve connections established but not energized until throttle is advanced in next step.	Operating cylinder moves reverser when reverser valves are energized (after the throttle is advanced).
Throttle Advance	Magnet valves in reverser and traction motor contactors (P switches) are energized.	Fuel supply increased and engine speeds up. See pneumatic lines on diagram. P switches close as soon as their magnet valves are energized.
Running at high speed.	Traction motor fields are shunted by: (a) Field shunt relays (FS) close at a set generator voltage, which energizes the field shunting contactors (M). (b) M contactors close to connect the field shunts.	Same as above, but no additional action.
Throttle retard.	Reverse of above.	Reverse of above.
Wheels slip.	Wheel slip relays pickup. They are sensitive to unbalanced voltage conditions at the traction motors. They close a circuit which energizes a valve in throttle line.	Throttle line air pressure is reduced. Fuel supply reduced. Pressure automatically restored when slip stops.



CONTROL SYSTEM DIAGRAM

FIGURE 27

DYNAMIC BRAKING

GENERAL DESCRIPTION

Road switchers are sometimes equipped with a dynamic braking system in addition to the standard air braking equipment. Dynamic braking is controlled entirely by the throttle and reverse lever. The energy involved in retarding the train by dynamic brakes is dissipated in the electrical equipment instead of in the brake shoes. At such times, the traction motors act as generators driven by the locomotive. This reduces wear and tear on brake shoes and, on long descending grades, eliminates delays which may otherwise be necessary for cooling wheels and shoes. Applications of the automatic brakes on the cars of a train are possible at all times, regardless of the setting of dynamic braking controls, but the air system is interlocked with the electrical circuits so that neither an automatic or independent application of locomotive brakes is possible during dynamic braking. Emergency applications may be made at any time in the usual manner.

OPERATION

Dynamic Braking instructions are substantially the same for various types of installations. The minor differences in the following text depend on whether there are one or two control stands and the type of blowers employed. The system will not function unless the dynamic braking cutout switch is in dynamic braking position (closed), and it is generally left in that position. The usual braking procedure may be summarized as follows:

1. Reduce throttle to "off". Wait about 10 seconds before setting controls for dynamic braking.
2. Move reverse lever to "Dynamic Braking" position. If there is more than one such position, use the one corresponding to the direction of travel. (Trip a small latch under the lever if necessary to release it.)

3. Place the throttle in the first notch until an ammeter reading is obtained, then advance gradually until the desired amount of dynamic braking is obtained, but keep the ammeter within the normal operating range.
4. If additional braking effort is needed, the usual automatic air application may be made simultaneously. (If the dynamic brakes do not function at all, the air brakes alone can be used in the usual manner.)
5. To resume normal operation, first move the throttle to "off", then move the reverse lever to the position corresponding to the direction of travel. Then use the air brakes or throttle with due regard to the conditions set forth in the following important paragraph.

NOTE: Dynamic braking differs greatly from air braking and therefore requires special attention by the operator in order to handle the train smoothly. The feel of the train is best obtained only from experience, but the principal fact to remember is that the train is bunched in dynamic braking. At very low speeds, the dynamic braking effort fades out and air brakes must be used to come to a complete stop. Whenever dynamic braking ceases, either because of the low-speed fade out, or because the engineer no longer desires to brake, be careful to avoid a quick run-out of the head end which may have sufficient force to damage drawbars.

Dynamic braking is not effective above certain maximum speeds. Check what that speed is for your locomotive (as posted in the cab), and if braking is needed at higher speed, use the air brakes until the speed falls within the dynamic braking range.

SUPPLEMENTARY INFORMATION

The following miscellaneous information may be useful to operating personnel at times, especially if they must investigate some irregularity in operation.

The changes in electrical connections are controlled by a system of relays which function automatically when the fore-

going manual controls are operated. The action is mainly as follows:

(a) The traction motor fields are disconnected from their armatures. The armatures are connected to dissipating resistors, and the fields alone are connected to the generator. The action of the throttle on generator output varies the traction motor field strength which results in a varying braking effort. Advancing the throttle increases the braking effort.

(b) Engine speed is not affected by throttle action because the throttle valve controlling the fuel supply is interlocked to give a fixed engine speed. The foregoing variation in generator output is obtained by the throttle's pneumatic action on the Carbonstat in the generator field circuit.

(c) If the traction motor blowers are mechanically driven, they must operate at full speed to cool the motors which are working as hard as during motoring. The throttle valve is interlocked with the dynamic braking controls to bring the engines (and blowers) to full speed automatically. (If the blowers are electrically driven, the engine is automatically idled by the throttle valve and blower speed is automatically regulated by a different interlocking arrangement.)

(d) The circuit is protected against overload by a relay across the dissipating resistor which, when overloaded, energizes a dynamic brake limiting valve. This valve acts on the load regulator to reduce the field circuit (and hence the braking effort), just as though the throttle was reduced.

(e) The locomotive wheels would frequently slide if subjected to both dynamic braking and air braking at the same time. A brake interlocking valve functions automatically to prevent their simultaneous application. (The emergency application is not interlocked.)

(f) Other protective devices may be installed according to individual specifications. If an alarm is connected to indicate operating failure in the fans on the dissipating resistors, avoid dynamic braking until the trouble is rectified. Do not use the dynamic brakes if the wheel slip buzzer sounds continuously, but intermittent sounding may be disregarded.

OPERATING DIFFICULTIES AND CAUSES

I. Engine Does Not Turn When Starting Button Is Pressed:

- A. Control switch open,—or fuse burned out.
- B. Engine stop switch open, if part of locomotive equipment
- C. Battery switch open
- D. Throttle not in the "idle" position
- E. Reverser not in the "off" position
- F. Multiple unit switch not in the correct position, if locomotive is equipped for multiple operation.

II. Engine Turns But Does Not Fire, or Continue Running After Releasing the Starting Button:

- A. Fuel tank empty.
- B. Emergency fuel cut-out valve is tripped. Reset.
- C. Overspeed stop has been tripped. Reset.
- D. Releasing start button before lubricating oil pressure has built up to 20 lbs.
- E. Low fuel oil pressure.
- F. Insufficient oil supply in the governor.

III. Engine Does Not Respond to Throttle Setting:

- A. Low control air pressure
  1. Low main reservoir air pressure
  2. Control air cut-out cock closed.
  3. Control air pressure regulating valve sticking. Try tapping it.
- B. Governor linkage disconnected

IV. Locomotive Does Not Move:

- A. Reverser not in the "forward" or "reverse" position
- B. Auxiliary generator switch open
- C. Traction motor cut-out switches open
- D. Hand brake still set
- E. Pneumatic throttle switch open

V. Engine Stops:
- A. Overspeed stop has tripped. Reset and notify maintainer if it continues to trip.
- B. Low lubricating oil pressure, causing the engine shutdown device to operate
- C. High water temperature, causing the engine shutdown device to operate (when provided on the locomotive)
- D. Emergency fuel cut-out valve has been tripped. Reset
- E. Fuel tank empty

VI. Low Fuel Oil Pressure:
- A. Fuel tank empty
- B. Emergency fuel cut-out valve tripped. Reset
- C. Sticking relief valves. Try tapping them

VII. Low Lubricating Oil Pressure:
- A. Low oil level
- B. Clogged pressure strainer. Turn the handle on top of the strainer two revolutions in the clockwise direction
- C. Sticking relief valves. Try tapping them

VIII. Engine Overheats:
- A. Low water level.
- B. Radiator shutter control not functioning properly. See page 30.
- C. Radiator fans not functioning properly.
  1. Check the "V" belts on locomotives having a belt driven fan.
  2. On locomotive having motor driven fans, check fuses. If O.K. see page 31 for manual operation.

IX. Air Pressure Too High or Too Low:
- A. Compressor governor cut-out cock closed
- B. Compressor governor sticking. Try tapping it

NOTE: Always notify maintainer as soon as possible when any operating difficulty is experienced.
Notify maintainer ***immediately*** if the trouble can not be corrected by the above suggestions.